Report for 2001SC3761B: Using Spatial Techniques to Assess the Contribution of Animal Agriculture on Watershed Impairment for the Saluda River Watershed in South Carolina

There are no reported publications resulting from this project.

Report Follows:

STATEMENT OF CRITICAL REGIONAL OR STATE WATER PROBLEM

As basic natural resources become more scare with increased population and development, various government entities come into conflict with each other over these resources. Clean water and clean air are basic resources any community needs to support life and maintain living standards. Already in the Southeast US, conflicts have arisen between communities over the right to clean water versus the need to develop economically. A prominent national example has been the dispute between Canton, NC on the Pigeon River and towns and citizens downstream from Canton. The question persists, does one community, in its efforts to develop a strong economic base have the privilege of spoiling water or air resources that must also be used by communities downstream or downwind? Answering these questions is more in the realm of law and land use policy. However, as these issues become more heated, there arises a need for clear fundamental research into cause and effect as it relates to clean water and air. In cases such as Canton, NC, a single paper mill can clearly be seen to impair out-flowing water quality. Much different is the circumstance such as the dispute between Greenwood and Greenville, SC. Greenwood takes its drinking water from Lake Greenwood on the Saluda River (Fig. 1). Upstream lies Greenville. The Reedy River, a tributary of the Saluda, flows through downtown Greenville. The upper reaches of the Saluda flow through the greater Greenville metropolitan area. Greenville has a famously protected municipal reservoir and prides itself on the quality of its drinking water. The Greenwood reservoir, on the other hand, shows many of the symptoms one might expect from a "downstream" water resource: sedimentation, nutrification, and algae blooms. Therein lies the debate. Water flowing into Greenville reservoir is clean. Water flowing into Lake Greenwood is much less so.

Professionals working in resource management, water quality, land use and such may feel there is abundant research tying land use/land cover to water quality downstream. Certainly much research has been aimed at this issue. What becomes apparent in listening to disputes between communities is the extent in which fundamental research does not translate to sound policy or even to informed debate. One community can assert, using "conventional wisdom", often supported somewhat by research, that agricultural land use is a severe stress on water quality. As such, it is the quantity of agricultural land on within the Saluda Watershed that may cause the impairment. This point of view gains support following well-publicized stream contaminations at swine farm sites in NC in the mid 1990s. The other community, citing other "common knowledge" claims that urban/suburban/industrial land use is the most damaging. Again, research may even be cited in support of this. What is missing is information tying the specifics of reservoir impairment to specific land use in the watershed above the impairment. In other words, in this particular case, what appears to account for the bulk of the impairment to the inflow of Lake Greenwood. Without this level of information, debates between communities regarding water quality cannot rise above accusation and finger pointing.

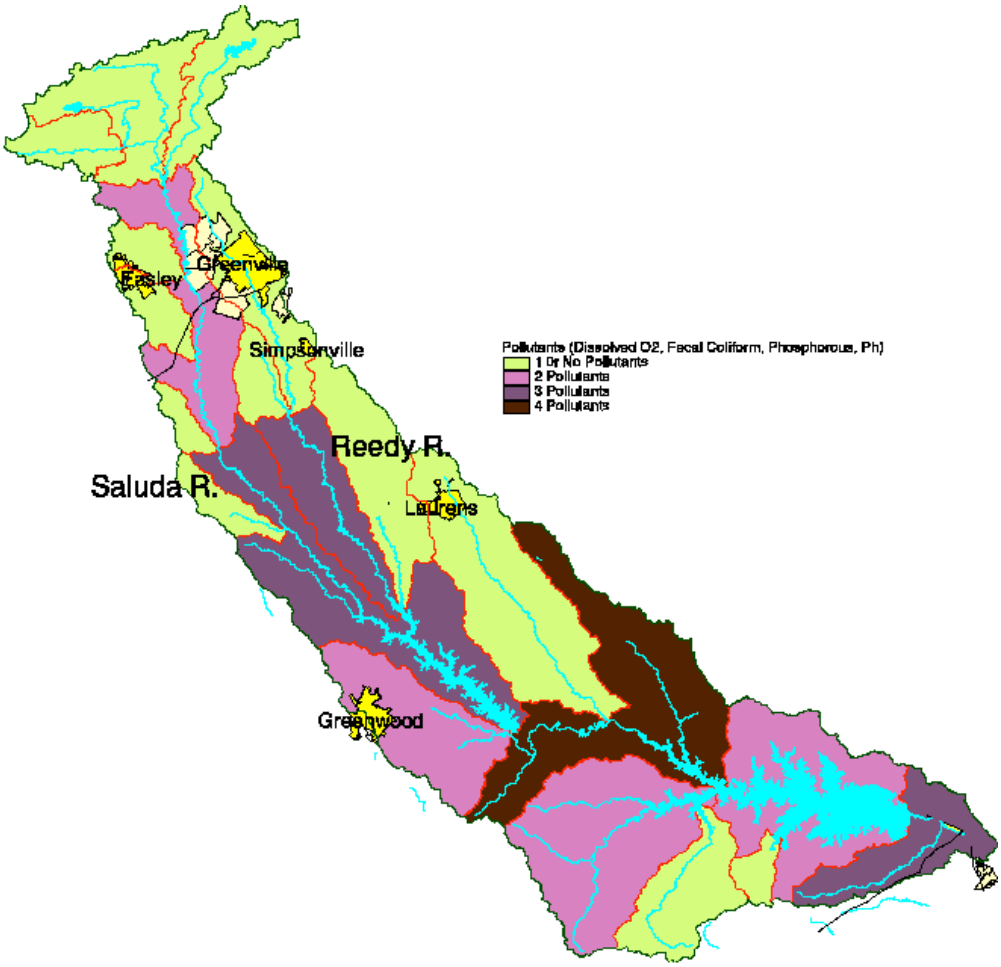

Figure 1.

STATEMENT OF RESULTS OR BENEFITS

For policy makers to make sound decisions on water quality they need sound information. Their information must be correct but also appropriate to the scale that they operate. Highly detailed studies showing the transport of sediment and nutrients across different land covers do not help a planner assess which of two possible sources of water impairment is most critical. Region wide studies showing trends in water quality also do not indicate whether those trends hold for a single watershed of interest.

We are seeking to provide a level of information targeted to the subject at hand. Do animal agricultural populations account for the level of impairment of tributary streams to Lake Greenwood? Do human populations better account for the impairments? In this way, we hope to provide a better level of information to the public debate on water quality. The issues are real and important to the communities involved, and only when research data be provided to policy makers in an understandable form can it be used in the public forum to guide land use policy.

NATURE, SCOPE AND OBJECTIVES OF THE RESEARCH

The proposed research effort seeks to clarify this specific water quality issue by using real, publicly available data, to relate land use in the various watersheds above Lake Greenwood tributaries to water quality from those tributaries. Specifically, we will try to determine if impaired tributaries are related more to agricultural animal populations or to human population.

This effort will be confined to the Saluda River Watershed above and including Lake Greenwood. This watershed includes the Reedy River tributary. The cities within the watershed are Greenville, Greenwood, Laurens, Simpsonville, and Easley, SC. There are 19 USGS, 11-digit hydrologic units within the Saluda River watershed.

An attempt to quantify the mechanism of impairment by collecting field data throughout the watershed would be well beyond the scope of this research funding. What we intend to do instead is use available, public data on human population, agricultural animal intensity, land use/land cover data, and water quality measurements on Lake Greenwood, to see which of these "domestic" animals populations might statistically account for more of the water quality impairment.

In parallel with statistical correlation, we will run EPA's BASINS model as a recognized benchmark with which to compare our statistical model.

METHODS, PROCEDURES AND FACILITIES

This effort intends to be less a data collection process and more of a data gathering, processing, and interpreting task. The input data sets will be publicly available animal and human population information supplemented with ongoing water quality data collected in Lake Greenwood , collected by Lynn Deanhardt Professor of Chemistry at Lander University. Other data such as land use and elevation models will be used to round out the processing.

First water quality information will be acquired on the tributaries of Lake Greenwood. These data are being collected continually for a research effort conducted by Dr. Deanhardt, funded by a private foundation. Several techniques were used to record levels of nitrate and phosphorous in lake water (2). These parameters are common indices of nutrient load.

The locations of these sample sites are fixed and known. We will build watersheds above these sites using USGS 30-meter Digital Elevation Models and GIS software. In this way the watershed boundaries will not necessarily correspond to USGS watershed boundaries, but will be specific to each sample point. The watershed boundaries will be used to accumulate the animal, human, and land use data much as they accumulate the water flow through the sample point.

The agricultural animal population will be derived from two sources. USDA agricultural census data from 1997 will provide animal counts. These data are currently on-line at the Strom Thurmond Institute and are coded by zip code. These data will be converted to per/acre values so that they may be later overlaid with watershed boundaries and summed to provide population by watershed. We will focus on cattle, swine and poultry populations from these data, though the data will be most useful in assessing cattle and swine population densities.

SC Department of Health and Environmental Concern or DHEC maintains data on agricultural facilities. These data are site specific, including spatial coordinates. These data indicate the type of facility, its location, and an indication of its size. This type of data is well suited for spatially specific modeling rather than assuming that all animal populations are distributed evenly throughout a zip code area. As such it is better suited for accumulating information by watershed boundary. For some animal populations such as poultry, the number of facilities is a better indicator of animal density that simple population of animals. We will use the data that best represents population density for each animal class.

US Census data from 1990 or 2000, summarized at the block or block group level will be used as the source of human population. These data show population in terms of individual people, households, families, and housing type. It is assumed that population alone will be sufficient for our analysis but the greater depth of data will be available if it is needed. US Census data is currently stored on-line at the Strom Thurmond Institute and used in support of several ongoing programs and research efforts. These data are linked to block, block group, and tract boundaries to provide adequate spatial resolution. Still, since the data is not aggregated by watershed boundary, it will need to be expressed in per acre units to allow for overlaying with watersheds.

We will need an overall assessment of land cover and land use for our parallel BASINS modeling. This data will come from SC Department of Natural Resources' (DNR) GAP analysis. This classification provides over 70 levels of land use information. This classification is made using 30 meter LANDSAT TM data and is of sufficient resolution to give an overall land use profile within each watershed boundary.

Task 1:

Using the derived watershed boundaries, animal and human population data will be aggregated by watershed, for each of the watersheds. Statistical regressions and correlations will be performed on this aggregated data. The goal of these analyses is to determine which populations can account for more of the variation in water quality for each sub-watershed. Further, this statistical analysis will seek to determine the proportion of water quality impairments accounted for by human and animal populations together.

Task 2:

Many water and land resource professionals are familiar with EPA's BASINS water quality and quantity model (3, 4, 5). This software is available within ESRI's Arcview GIS package. BASINS uses land use GIS data with many other parameters, including rainfall and topography to predict the quantity and quality of water flowing through a watershed pour point. BASINS can be calibrated using available water quality information. We will use the data from Lake Greenwood for this purpose.

The primary purpose of using the BASINS model in parallel with Task 1 is to provide a comparison of our model with a familiar index of water quality and not as a goal of its own. The purpose of this project is to provide specific water quality information for public policy

professionals in a form readily understood by the public. Still we recognize the need to relate this analysis to accepted and familiar models in order to gain the trust of land and water resource professionals and provide a context for our model.

RELATED RESEARCH

In the wake of well-publicized water contamination problems in NC involving large-scale swine farms, there was great concern in South Carolina over the prospect of a similar problem in SC. The public was justifiable concerned with water quality and the prevailing public opinion was tilted toward the assumption that animal agriculture was a primary contributor to water pollution. The SC legislature, in the mid to late 1990s, enacted a very restrictive farm bill, essentially curtailing large scale hog farms, partially based on this public opinion, and perhaps without a sound scientific basis. The SC Agricultural Extension sought to determine public sentiment on agriculture and water quality. SC extension conducted surveys and compiled data that was later published in a book "Animal Agriculture in South Carolina: A Fact Book." The Strom Thurmond Institute contributed to this effort by creating maps of agricultural animal populations and watershed impairment. These maps and associated analyses were found in the article "Spatial Relationships of Polluted Streams, Animal Agriculture, and Human Population in South Carolina Watersheds" (1) in 1998. USDA Agricultural Census data from 1992 were displayed on top of USGS 8-digit watersheds, coded by SC DHEC 303d assessment of impairment. The 303d impairment information indicates whether or not a watershed is impaired on a certain parameter, including dissolved oxygen, fecal coliform, phosphorous, and pH. This information is then classed 0 (unranked), 1, 2, or 3 based on the number of impairments. No statistical analysis was attempted on this data. This was simply a mapping of available data. The maps seemed to suggest, though, that animal agriculture was not the only contributor to water quality impairment, at least in SC.

When the maps were published, the level of public, government and farm industry interest in the maps was striking. Many pointed out some flaws in this simplified mapping approach to the issue. Among the weaknesses were:

- The maps were made using 8-digit hydrologic units for watershed impairment, which is too coarse in spatial resolution to truly assess site specific impacts on water quality,
- The "assessments" were purely visual interpretations of the maps and not supported by statistical analysis,
- DHEC's 303d assessment is somewhat coarse and difficult to translate into quantifiable water quality indexes, and
- Many people disputed the conclusions inferred from the maps.

There was sufficient interest in this analysis to fund a second phase of the project to address some weaknesses of the first project. In the second phase, updated data were used and the spatial resolution improved:

- USGS 11-digit hydrologic units were used, greatly increasing the spatial resolution of the water quality data.
- Updated Agricultural census data from 1997 were used.
- Agricultural Census data was supplemented with SC DHEC animal facility data to give better spatial resolution to the animal population data, showing the spatial pattern and areas of concentration of agricultural populations.

- Statistical, canonical regressions were performed to quantify the relationships between animal agriculture populations and water quality impairments.

This project still used a statewide, macro approach to the issue and while showing overall patterns, did not show how animal populations might affect water quality in specific areas. This project is ongoing, but preliminary statistics indicate that there is a weak but significant correlation between animal agriculture populations and watershed impairment ($F=2.4140$ $R^2 = .259$). This analysis seems to support the visual information in the previous maps that animal agriculture alone does not account most of the variation in water quality in watersheds.